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UNSAFE ACTS AND UNSAFE CONDITIONS: DEVELOPMENT OF A PRELUDE MODEL

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Construction safety management has long utilised the concepts of unsafe acts and unsafe conditions within incident and accident reporting processes. Unsafe acts are often considered to be the greater concern; with figures of approximately 80-90% of accidents attributed to unsafe worker behaviour, although unsafe conditions remain relevant. It has also been argued that both play a part in safety, as manifest in highly complex accident causation models, yet industry often remains reliant on the simplistic categorisations of acts/conditions within accident reporting processes and safety observations undertaken in practice. This utility and common practice must be recognised, and it can be suggested that acts and conditions are firmly interlinked. Drawing on a large dataset of nearly 4,000 Safety Observation Reports from a large infrastructure construction project, investigation of the way in which incidents are categorised is explored and then, via content analysis of a purposive sample of individual reports, the reality of how the acts and conditions combine and interrelate is evaluated. Findings revealed significant inconsistency in the application of the categorisations of act or condition, and utilisation of the process to apportion individual blame through 'unsafe acts'. Grounded in the data, a conceptual model is developed that recognises the state of 'unsafety' of both acts and conditions, but also explores the preludes to both. It can be suggested that within the construction context there are relatively few precursors that produce unsafe acts or conditions in practice, and employing these in practice would provide greater insights, enhancing utility without adding significant complexity. Integration of this model within the reporting process would enable management to better use reporting data in the development and implementation of focused interventions, albeit still grounded in the familiar unsafe acts and unsafe conditions identified on their projects.

Keywords: safety observations, unsafe acts, unsafe conditions, taxonomies

INTRODUCTION

The historical development of occupational health and safety management in construction has in part dictated its lexicon. Early focus was on the identification and mitigation of physical risks within the workplace, through the provision of machine guards and controls (Lingard and Rowlinson 2005) which led to prescriptive management approaches which focused on unsafe conditions through mechanistic regulations. Subsequently, as the number of accidents decreased focus shifted onto unsafe acts, through approaches such as behaviour-based safety (Lingard and Rowlinson 2005), goals and feedback programmes, and most recently notions of safety climate and culture have emerged (Choudhry et al 2007).

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A consequence of this language of safety is the way it has directed thinking, particularly in the areas of safety reporting for accidents and near-misses, towards unsafe acts or unsafe conditions as an either/or situation. However, accidents are often highly complex in reality, and to use such a simplistic dichotomy in reporting and subsequent investigation is likely to limit the learning potential of an incident. Indeed, although acts have come to the fore in terms of management focus, evidence has shown that organisational factors are indeed critical (Lingard and Rowlinson 2005); whilst Hinze (1996) argued that it is always a combination of physical conditions and worker actions that is the true cause of safety accidents on sites.

Despite such evidence, unsafe acts and unsafe conditions often remain segregated in practice, accident and near miss reporting seeking to categorise one or the other, with no potential for overlap. Academic advances in accident analysis have led to the development of ever more complex approaches, grounded in systems thinking and organisational failure models, yet their utility has been questioned (Hovden et al 2010). Indeed they are rarely used in practice, and would be challenging to apply to near-miss reporting, which is often large scale in terms of volume, but with relatively little management time available to record, analyse and act upon them.

Drawing on a large database of nearly 4,000 safety observation reports that have been categorised as either unsafe acts or unsafe conditions, this work seeks to explore empirically the consequences of this dualistic approach, and how acts and conditions combine in practice. It reflects on the utility of this approach to practice, and how it can form the basis of a simpler 'prelude model' of safety.

CONTEXT

Unsafe Conditions and Unsafe Acts, and more Systemic Thinking

Early health and safety management was grounded in the elimination of unsafe working conditions, indeed the earliest UK safety legislation sought to address the mechanistic problems of exposed mill-gearing in the factories of the industrial revolution. Developments in technology brought new hazards and risks into workplaces, and key concerns were to "... find the technical means to safeguard machinery, to stop explosions and to prevent structures from collapsing" (Hollnagel 2014:24). Within the UK construction industry, unsafe conditions are often addressed through rigorous legislation, such as that found within Part 4 of the Construction (Design and Management) Regulations 2007, which sets out amongst other things how stability of structures must be maintained, how excavations must be managed and how good order can be kept on sites.

Alongside such unsafe conditions, relating to the work space, can be found the concept of unsafe acts, relating to the behaviour of the people who work there. As Hollnagel (2014:30) states, "the idea that human error could be used to explain the occurrence of adverse events was eagerly adopted". Application of cognitive theories also enables 'explanation' of such unsafe acts, examples including the optimism bias, that everything will go right despite risks being taken, the overconfidence barrier, and the planning fallacy, which results in optimistic predictions about how long a task will take (Baron et al 2006) which can result in cutting corners and risk taking when deadlines approach. More generally, Kletz (2001) suggested that most unsafe acts were the result of a moment's forgetfulness or aberration, others the result of errors of judgement, which can also be traced back to inadequate training or supervision. Within the construction industry, Rawlinson and Farrell (2010) observe that a high

tolerance to risk taking is evident, allowing intentional unsafe acts to form part of everyday site life.

A combined approach is to make technology failsafe so unsafe acts cannot not lead to an accident, rather than educate workers through training programmes (Swuste et al 2014), however this is highly problematic within the construction industry, given the nature of the work. Indeed, the continuing development of technology within the workplace has led to increasing complexity and coupling between tasks and activities, therefore interactions cannot be fully planned, understood or anticipated (Leveson 2004). This is particularly relevant when many different subcontractors and long supply chains create complex relationships on sites, and have been found to have negative effects on safety (Manu et al 2010). Although single failure prevention is often built in to processes and equipment, this means that in practice accidents have shifted to more complicated occurrences with two or more cumulative failures, which are harder to predict and therefore harder to prevent. (Hollnagel 2004:3).

These ideas of organisational failure (Hollnagel 2004; Hovden et al 2010) and systemic safety (Dekker 2006) bring together unsafe acts and conditions. Unsafe acts have become a symptom of deeper latent problems within projects or organisations, the management system creating situations, or rather unsafe conditions that can encourage or even force human errors within certain contexts (Perrow 1999; Dekker 2006). As Whittingham (2004:34) states, most violations (unsafe acts) also have a systemic underlying cause that effectively ‘encourages’ them. Within the construction industry competitive tendering for work winning (Morton and Ross 2008); and bonus and payment schemes that encourage speed and risk taking behaviours (Fellows et al 2002; Spanswick 2007) have both been highlighted as unsafe conditions, or latent safety defects, in industry operations. However, as Whittingham (2004) argues, organisations are often unwilling to look too closely at the system faults which caused the error, and would rather focus on the individual who caused it; emphasising the unsafe act rather than the systemic cause.

On construction sites, where the workplace is subject to continual changes, different resources, poor working conditions, tough environments and complex co-ordination of different trades and subcontractors (Pinto et al 2011), performance variability can be argued to be a necessity, therefore to isolate and label unsafe acts within such (potentially unsafe) conditions seems incongruous. However, this has not stopped continued focus on unsafe acts, embedded as they are in the historical language of safety. Indeed, both acts and conditions, independently and combined in systems thinking, still hold significant influence on the way accidents, incidents and near misses are investigated both academically and in practice.

The Influences of Accident and Incident Investigation

Statistics form one of the most prominent safety indicators of an industry, providing evidence of safety management in practice. Accident statistics are themselves lagging indicators (Hinze et al 2013), and learning from past indicators is a key process for understanding why accidents occur on sites and how future performance can be improved (Manu et al 2010). Yet investigations of accident causality have developed highly complex, and at times rather unfathomable, approaches to investigating incidents from a variety of underlying theories and approaches. Indeed, Grabowski et al noted the panoply of approaches, and that there have been “... few efforts to harmonise or synthesise the models and methods” (2009, p1187), resulting in an incoherent body of work. The accident process itself has also seen development from

linear, causal models, which suggest accidents are simply the sequential result of technical factors, human error or organisational problems (Hovden et al 2010), to more complex, integrated approaches. As Grabowski et al (2009) note, whilst some accidents will be the result of immediate causes, cascading through an error chain, others are much more complex with non-linear interdependencies, drawing on systems thinking for their theoretical foundation.

One of the main goals of accident investigation has been the identification of the 'root cause', and consequently the apportioning of blame (Whittingham 2004). Accidents are seen as evidence of error or failure, through either an unsafe act or the emergence of an unsafe condition, and therefore accident investigation becomes the quest to identify the responsible individual behind the error (Dekker 2011). It can be argued that this has perpetuated 'human error' as a prominent causal factor in accidents (Whittingham 2004), as the cause becomes easily identifiable as one of Reason's (1990) rule, skill and knowledge-based errors or occasional or routine violations. Yet the quest for root causes has been challenged on a variety of levels, not least the potential for over-simplification (Grabowski et al 2009). Kletz (2001) suggested that root cause has an air of finality about it, not always helpful, given that the cause of many accidents is actually gravity. Hollnagel (2004) suggested that causes are not sought simply for learning, but from desires for certainty, and the notion we gain knowledge that can be used in future accident prevention.

Systemic, management and organisational factors have also been identified and incorporated into accident thinking. For example, Hollnagel (2004) proposed a Functional Resonance Accident Model (FRAM) based on the concepts of emergence. Ferjencik (2011) discussed the notions of singular causality, general causality, contextual factors, contributory factors and causal factors in the development of an Integrated Procedure of Incident Cause Analysis (IPICA). Leveson (2004:257) went further than organisational boundaries in suggesting a general form of a model of socio-technical control which also acknowledges the influences of legislation, regulations, certifications, and law.

From the utilitarian perspective, the shift to systemic and organisational thinking has added considerable complexity to the process of accident and incident investigation. Although it is arguable that a contextual understanding of an accident is a vital part of its investigation, in order to appreciate the social and technical systems that surrounded it (Leveson 2004) and enable the development of explanations, rather than isolated root causes (Hollnagel 2004), it has been questioned whether they have seen utilisable fit with the current, existing realities of work (Hovden et al 2010). There is the potential for the level of detail and the interactions of these details to develop incoherence and impracticality, as they increase in numbers and interrelationships. Indeed, it has been suggested that this increasing complexity is incompatible within traditional linear accident models and whether new approaches are needed (Hovden et al 2010), exploring non-linear perspectives (Ferjencik 2011). This may however raise its own problems, as the representations and communication of such approaches may prove too complex to practically deliver.

Indeed, uptake of complex approaches to investigation has been limited, or only utilised when serious incidents, such as fatalities, occur. The need for investigation to support learning, the human desire for categorisation and management, and the desire to apportion blame where necessary, has arguably resulted in the reliance on two fundamental root causes; unsafe act and unsafe conditions. Therefore, rather than

seek complexity, it is this basic approach that should be empirically explored to ascertain its benefits and limitations, whilst enabling consideration of the relationships between these two root causes. In taking a utilitarian perspective, and accepting of the desire to retain simplicity and ease of use on sites, it is hoped that a theoretical model can be produced which fits with the site context, yet is able to inform improvements in accident reporting and learning on sites.

METHODS

Between March 2013 and July 2014, 3956 safety observation reports were collected from a large UK infrastructure construction project (approximate value £800M). The collection of safety observations from construction personnel is common practice on large projects, and for this dataset any manager or foreman was able to enter details in to an online system for the attention of the safety department. The person entering the report categorised it initially as a type of ‘observation’, either an ‘Unsafe Act’ or an ‘Unsafe Condition’ or as an example of ‘Good Practice’, and subsequently this observation was allocated to one of 27 different work ‘categories’. A project safety advisor ‘checked’ this categorisation, and could amend it if necessary, potentially dismissing it as a non-safety issue, or authorising it for further action.

A mixed methods approach has been used with these data. Quantitative analysis was carried out to initially determine the allocation of observations, and then to establish the relative quantifications of the ascribed categories beneath them. While a full content analysis of all the safety observations would reveal more about the actual practices and nature of activities that resulted in the safety report, it is beyond the scope of this paper. Therefore a qualitative approach was made to just two categories, considered a purposive sample, which could then be examined in depth, utilising content analysis (Tonkiss 2004) to develop a taxonomy of the data. A taxonomy can reveal the principles underlying a classification, for example Garrett and Teizer (2009) provided a taxonomy for human error awareness in construction safety. Repeated passes of the data enabled the researchers to explore the data itself and also undertake a process of re-framing, exploring the potential for alternative categorisations than those originally made, through the lens of the literature.

FINDINGS AND ANALYSIS

Quantitative Analysis

Of the 3956 safety observation reports, 2128 were categorised as unsafe conditions, 697 as unsafe acts and 1131 as good practice. Here only ‘unsafety’ is considered and therefore the ‘good practice’ observations were removed from the dataset, resulting in 2825 records. With just over 75% of the observations considered to be unsafe conditions these data can be considered surprising – they imply that the majority of unsafe incidents are derived from situations that are not influenced by human actions. However, this may also be a reflection of the difficulties of observing fluid and momentary acts when compared to static and unchanging conditions.

A fuller picture of the dataset and of the range of categories to which the reports had been ascribed can be found in Figure 1, which presents graphically the range of categories as assigned beneath the observations of unsafe acts and unsafe conditions.

In almost all categories it can be seen that the number of unsafe conditions exceeds the number of unsafe acts, with the exception of ‘behaviour’. The inclusion of this category in itself is interesting – it is neither a work type (such as excavations or

lifting) nor an organisational function (such as permits, PPE or welfare). That there are any ‘unsafe conditions’ that can be attributed to behaviour is also interesting and the data overall suggests either misunderstanding in the categorisation of the safety observations, or is the manifestation of the complexities of incident reporting when limited to just categorisations.

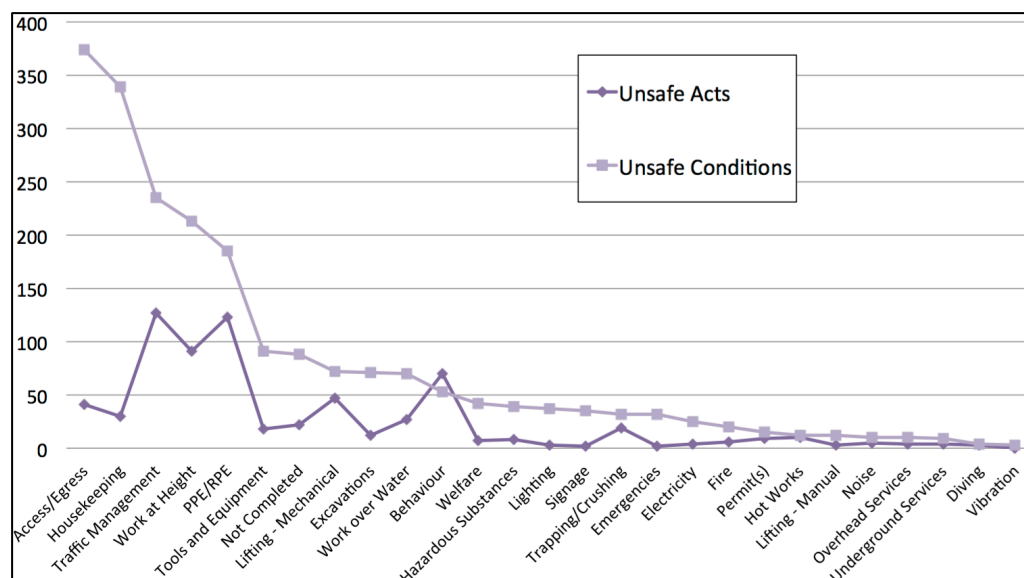


Figure 1: Categorisation of Unsafe Acts and Unsafe Conditions

Qualitative Analysis

In order to further explore the data, and these apparent inconsistencies, the cases under the ‘behaviour’ category for both unsafe acts and unsafe conditions, were extracted from the wider dataset, a total of $n = 114$ records.

The process of this analysis was revealing in itself. In the initial dataset, 48 observations were recorded as unsafe conditions but many of these did not fall under a definition of situations that were unsafe through non-immediate human means. For example, one report suggested that “Welder welding without screen in internal stair” was an unsafe condition, presumably because the correct equipment was not present, but in the researchers’ interpretation the lack of a screen in a particular area should not be the immediate focus; rather the fact that the welder chose to continue welding without a screen present is itself poor human judgement and thus an unsafe act. This consideration of ‘human means’ was used as a ‘benchmark’ for classification, while at the same time acknowledging it is arguable that any classification process is inherently subject to interpretation, as demonstrated by the data explored here: overall, of the 48 initial such observations only 5 remained as such following the re-framing process; 90% were changed by the researchers. This finding illustrates the complexities involved in deciding at what point an act, or number of acts, eventually ossifies into a condition.

However, those observations that remained ‘unsafe conditions’ following the re-framing process were still supported by the sub-categorisation of behaviour. Here, and to further develop the previous argument, the underlying premise was that an act had initiated the condition, although the line between them had been drawn at the level of the categorisation rather than the observation. For example, the observation that “road pins for gulley setting out have no protection either place caps or remove pins”, can be related to behaviour, or rather the omission of the behaviour to place

caps on the pins, but it could also relate specifically to excavation works. Although this analysis arguably supports more complex, non-linear and emergent approaches to analysing safety incidents, given the reliance on acts and conditions it can be suggested that what would actually be of greater utility would be a clearly defined and shared understanding of the ‘line’ between acts and consequentially emergent conditions, integrating this concept of behaviour within it.

Another notable aspect of the data, revealed by the analytical process was the prominence of finger pointing or blaming individuals for their behaviour. For example “Safety rep parking vehicle in live traffic route to speak to his supervisor”; “Security guard not using walkways, challenged and re-routed to walkway” are clearly identifying individuals with some level of authority. While many unsafe act observations report simply the behaviour of an unidentified individual, 37% directly identify the individual by name or by the company they work for or by the registration number of their vehicle. Such data strongly indicates highly complex social and organisational issues at play that have seeped into the safety observation process, in part those who create and enforce the policies are readily punished by others for their violation. Even where individuals are not named, the desire to lay blame can be found within the data, a fundamental need in incident reporting as identified by Whittingham (2004) and Dekker (2011).

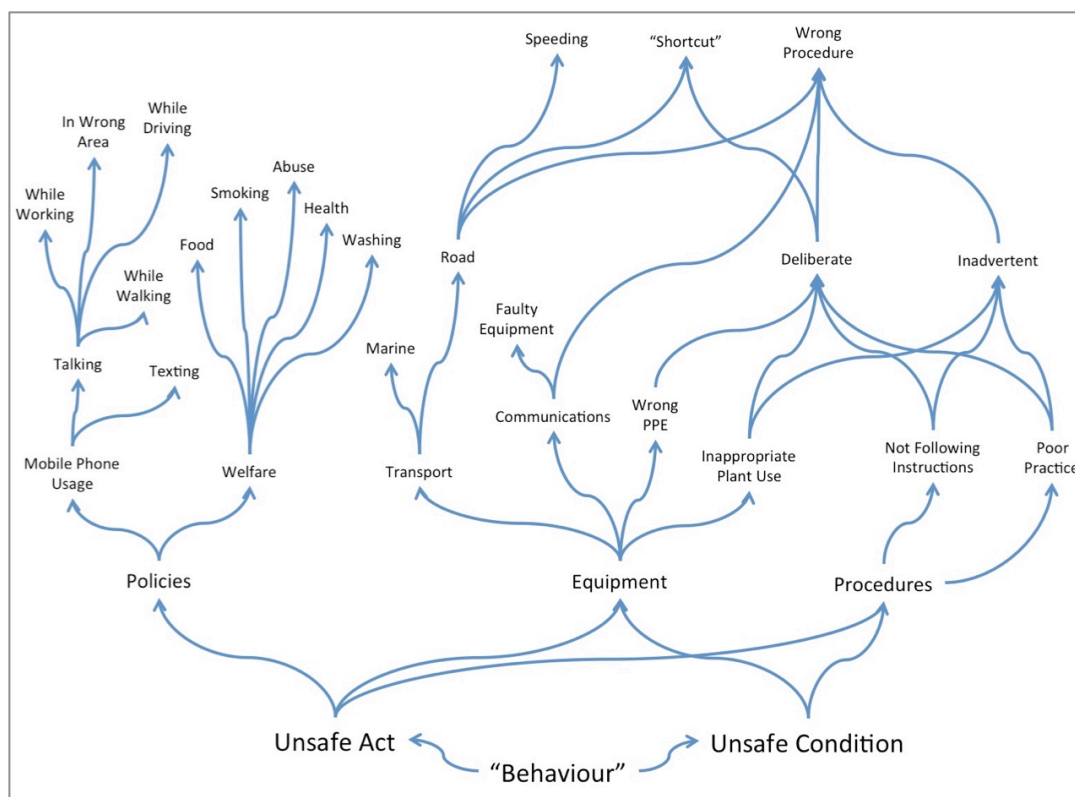


Figure 2: A taxonomy of the Behaviour category of safety observations

The prepared taxonomy itself, seen in graphical form in Figure 2, was also of interest; both behavioural acts and conditions easily assigned to either policy, procedural or equipment categorisations, suggesting that a more useful assignment could be made at a more ‘detailed’ level within the data, rather than the traditional act/condition dichotomy. As the taxonomy developed, ‘deliberate’ and ‘inadvertent’ also emerged as key categorisations, deliberate further supported by notions of ‘shortcuts’ and deliberate violations of procedure.

In order to provide a ‘check’ on the findings from the ‘behavioural’ categorisation data, a taxonomy was also prepared for the ‘hot works’ category. This was a much smaller sub-set of the data (n = 22 reports that were either unsafe act or unsafe condition), yet the same taxonomy categories emerged from this data. The only category present in hot works but not in behaviour was ‘missing equipment’. This is itself of interest, as it could be suggested that equipment has developed beyond its inherent unsafety, the initial causes behind historical concerns around unsafe conditions (Hollnagel 2014), and rather it is unsafe acts involving this equipment that have become more relevant to practice. The taxonomy for hot works can be seen in Figure 3.

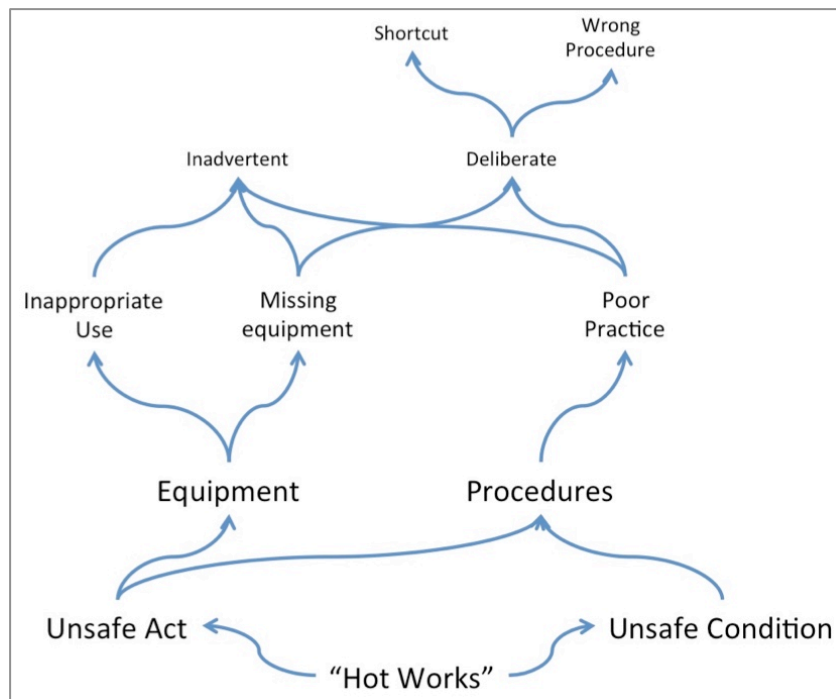


Figure 3: A taxonomy of the Hot Works category of safety observations

In the preparatory process of this second taxonomy, similar observations were made as for the behaviour category. Reports again appeared to be incorrectly categorised as unsafe condition when could be more appropriately labelled unsafe act (50% were changed) and those that identified individuals or companies and could be considered ‘blame reports’ (27%), though both were not to the same extent as for ‘behaviour’.

THE PRELUDE MODEL

The ease with which the same levels were identified in the preparation of both taxonomies suggest there may be a common pattern to how unsafety can be understood, in terms of preludes rather than ‘root causes’ (Grabowski et al 2009). Generally, equipment and procedures can be identified in level 2; poor execution in level 3; inadvertent or deliberate at level 4 with either shortcuts or wrong choice of procedure at level 5. By reversing these levels, a tentative ‘prelude model’ of unsafety development emerges.

These ideas are explored in Figure 4, a conceptual prelude model of unsafety development between unsafe acts and unsafe conditions.

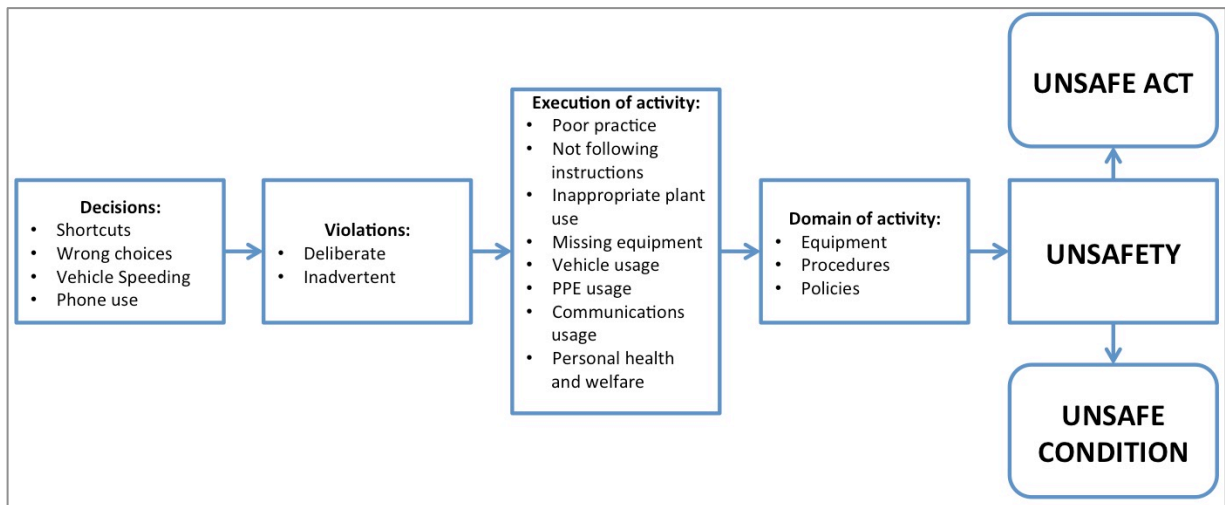


Figure 4: The development of unsafety – a conceptual model

CONCLUSIONS

Through content analysis of 136 Safety Observation Reports taken from a larger dataset of nearly 4000, a greater understanding of the nature of unsafety as perceived by those undertaking construction work emerges. The process of analysis revealed both complexities and subjectivity within the reporting process, and an underlying desire to apportion blame. This raises questions of the motivation for creating reports; to point fingers, particularly at those in authority, or to genuinely attempt to improve conditions. Projects and organisations undertaking safety reporting of this nature should seek to ensure this does not undermine the utility of the exercise.

The categorisation of unsafe act and unsafe condition was found to be highly subjective, and likely dependent first on a robust definition of what constitutes an ‘act’ and what a ‘condition; and secondly on individuals’ interpretation of this definition. Many reported unsafe conditions were deemed by the researchers to actually be unsafe acts. In some ways this is contrary to the conclusions of Whittingham (2004), who argues that organisations would rather focus on the error of the individual. Yet the contextual descriptions of each observation challenge this further – while many clearly indicate human error, most unsafe acts were categorised as systemic conditions. If such labels are to be used then clearer and objective definitions are needed for consistency of reporting, to mitigate the subjective nature of the process.

Preparation of taxonomies on two subsets of the overall data enabled the development of a conceptual prelude model of how unsafe acts and unsafe conditions may develop and form. The nature of how unsafety develops was very similar for both acts and conditions and rather than as two ends of a single spectrum, they are perhaps instead two artificial constructs superimposed on a development of unsafety, that has roots in decisions made either consciously or unconsciously; deliberately or inadvertently. It is suggested that further research explore this prelude model in practice, including the utility of its application to existing reporting processes to ensure its ability to enhance, rather than over-complicate, existing industry reporting procedures.

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